EXHIBIT D

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DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Industrial Application] This invention relates to the simulation system which enabled asynchronous communication with the virtual device in the simulation development environment of I/O device mounting communication system in detail about an I/O communication link simulation system.
[0002]
[Description of the Prior Art] When developing conventionally the communication system which used the I/O device by the general-purpose development machine [for example, a UNIX (UNIX is registered trademark) machine], three kinds of development models as follows have been tried by the limit of hardware.
** Since the development machine is not supporting the I/O device when an I/O device cannot be used, as shown in drawing 10 , perform the loop back by the upper layer of a device driver.
** As shown in drawing 11 , when the loop back communication link which used the I/O device is possible A development machine is equipped with one pair of I/O devices, and it connects and acts as the loop back of between devices with a telecommunication cable. Development and the communication link test of not only application but a device driver or firmware can be performed.
** As shown in drawing 12 , prepare the master system of an I/O device, and one communication system completed as a master system when a communication link was possible, and connect with a development machine with a telecommunication cable. Like the above-mentioned **, the top in which the development and the communication link test from application to the firmware of a device are possible, since it is not the loop back, analysis of operation is easy.
[0003]
[Problem(s) to be Solved by the Invention] However, there are the following problems about the above-mentioned ** thru/or **. That is, in **, development environment can be built easily, but there are the communication link test of a device driver not being performed and a defect that the simulation of the complicated communication link phenomenon cannot be carried out. Moreover, in the above-mentioned **, in order that I/O interruption may occur frequently and a I / O data may go the inside of the same machine back and forth bidirectionally, there is a problem that analysis of operation is complicated. Furthermore, in the above-mentioned **, since a master system does not exist at the time of new development, there is a problem in respect of practical use. The purpose of this invention solves these problems, builds the simulation development environment which does not receive a limit of the hardware in the communication system which uses an I/O device, can perform development and the communication link test of communication link application and a device driver on a general-purpose development machine, and is to offer the I/O communication link simulation system which can carry out the simulation of the real-time system which mounted the I/O device.
[0004]
[Means for Solving the Problem] The OS section which has room where an interprocess synchronous function and multiple processes can share this invention, and a software interrupt function manager in

order to attain such a purpose, The I/O communication system simulation process section which carries out the simulation of the communication system real on a plane correctly on a machine, It is prepared for every I/O device, consist of the virtual device server section equipped with a virtual device server which carries out the simulation of the actuation of a device faithfully on a machine, and a function which said OS section offers is used. It is what carries out the simulation of the asynchronous I/O process of an I/O device to a driver by asynchronous communication between an I/O communication system simulation process and a virtual device server. By asynchronous communication which realizes a data receiving interrupt request when the completion interrupt request of transmitting or a virtual device server when a virtual device server completes transmission to a Request to Send of communication system receives data It is characterized by being characterized by carrying out the simulation of the real-time system which mounted an I/O device.

[0005]

[Function] By asynchronous communication which realizes a data receiving interrupt request when the completion interrupt request of transmitting or a virtual device server when a virtual device server completes transmission to the Request to Send of communication system receives data, the simulation of the real-time system which mounted the I/O device is carried out. Processing to the interrupt request of a virtual device server is performed as follows.

** Judge whether a device can interrupt communication system by the interprocess synchronous function at the time of the interrupt request from a device. If interruption is possible, the reclaim of interruption is forbidden, and it waits until it becomes possible, if interruption is impossible.

** Judge whether modification of a bit field is possible by the interprocess synchronous function. If modification is possible, other processes are forbidden from changing, and it waits until it becomes possible, if modification is impossible.

** Set the status bit applicable to the device of an interrupt request to 1.

** Make communication system generate a software interrupt.

** Cancel prohibition of modification made by the above-mentioned **.

[0006] Moreover, the following processings are performed about the interrupt handler of communication system.

** Judge whether modification of a bit field is possible by the interprocess synchronous function. If modification is possible, other processes are forbidden from changing, and it waits until it becomes possible, if modification is impossible.

** Look for interruption of whenever [of the highest priority] out of the interruption status bit field, and cancel prohibition of modification made by the above-mentioned **. And if the interrupt has occurred, the interruption processing will be performed, and a handler will be terminated if the interrupt has not occurred.

** Process the above-mentioned ** again.

** Clear the status bit applicable to the interruption to 0.

** Cancel prohibition of process modification in processing of the above-mentioned **.

** Cancel reclaim prohibition of interruption which the virtual device server set up, and return to processing of the above-mentioned **.

[0007]

[Example] This invention is explained to details below. Drawing 1 is the theoretic block block diagram of the I/O communication link simulation system concerning this invention. In drawing, it is the virtual device server section in which 10 has the I/O communication system simulation process section, the OS (OS is the abbreviation for operating system) section with general-purpose 20, the virtual device server 1 of plurality [30] - N. In addition, P in drawing expresses the process on a versatile OS. The I/O communication system simulation process section 10 is the process section which carries out the simulation of the communication system (communication link application, a communications protocol, device driver) real on a plane correctly, and realizes transmission and reception with an I/O device by asynchronous communication between processes with the virtual device server section 30.

[0008] The OS section 20 has the interprocess synchronous function part 21, the room 22 which can

share two or more processes, and the software interrupt function manager section 23. The interprocess synchronous function part 21 At the time of the interruption status bit change field used when communication system and the virtual device server section 30 interrupt and the status bit field (it mentions later about this interruption status bit field) is written, ** A exclusive control device, When the virtual device server section 30 generates an interrupt request, ** In every [of interruption] class (class of device) It is for making the race condition of two controlling mechanisms of a exclusive control device avoid at the time of the interrupt request which checks whether the interruption processing of communication system to the last interruption is completed, for example, a semaphore etc. corresponds to this.

[0009] As for room 22, access is possible also from communication system and the virtual device server section. On the system, it arranges to the I/O access space which can share a device control register and a I / O data. Therefore, also in communication system and a virtual device server, to the sharable address space, the device control register and the I / O data have been arranged, and common use of the source program of a driver is mutually realized to it. Even if it sets, it shares a part. Moreover, in simulation environment, it interrupts on this shared memory space, and the status bit field is also assigned. Here, the interruption status bit field is explained. In order to carry out the simulation of two or more hardware interrupt by one kind of software interrupt, the status bit field as shown in drawing 2 is prepared. And in order to distinguish interruption, 1-bit area is secured to every [of interruption] class (class of device). Bit field length is equal to the class of interruption. When a virtual device server requires interruption, the bit concerned is set to 1, and it is reset by 0 when communication system terminates the interruption processing. The software interrupt function manager section 23 registers an interrupt handler, and carries out the simulation of two or more hardware asynchronous interruption. Moreover, it also has the function to perform automatically the handler which the user defined at the time of interruption, and the function to forbid interruption in a critical region.

[0010] The principle of operation of the asynchronous communication in such a configuration is explained below. Asynchronous communication is generated by the following main I/O (I/O) interrupt requests from a virtual device server.

(1) Interruption when a virtual device server completes transmission to the Request to Send of communication system (the completion interruption of transmitting).

(2) Interruption when a virtual device server receives data (data reception interruption).

[0011] Order is explained for the principle of operation to this interrupt request later on.

A. I/O interrupt request [of a virtual device server] ** -- judge whether a device can interrupt communication system using a exclusive control device at the time of the interrupt request of the interprocess synchronous function part 21 at the time of the interrupt request from the device concerned. If interruption is possible, the reclaim of interruption is forbidden, and it waits until it becomes possible, if interruption is impossible.

** Judge whether modification of a bit field is possible using a exclusive control device at the time of the interruption status bit change field of the interprocess synchronous function part 21. If modification is possible, other processes are forbidden from changing, and it waits until it becomes possible, if modification is impossible.

** Set the status bit applicable to the device of an interrupt request to 1.

** Make communication system generate a software interrupt.

** Cancel prohibition of modification made by the above-mentioned **.

[0012] B. Judge whether modification of a bit field is possible using a exclusive control device at the time of the interruption status bit change field of the interrupt handler ** interprocess synchronous function part 21 of communication system. If modification is possible, other processes are forbidden from changing, and it waits until it becomes possible, if modification is impossible.

** Look for interruption of whenever [of the highest priority] out of the interruption status bit field, and cancel prohibition of modification made by the above-mentioned **. And if the interrupt has occurred, the interruption processing will be performed, and a handler will be terminated if the interrupt has not occurred.

** Process the above-mentioned ** again.
** Clear the status bit applicable to the interruption to 0.
** Cancel prohibition of process modification in processing of the above-mentioned **.
** Cancel reclaim prohibition of interruption which the virtual device server set up, and return to processing of the above-mentioned **.
By the above actuation, the simulation of the real-time system which mounted the I/O device on the general-purpose development machine can be carried out.
[0013] Drawing 3 is example drawing of the simulation system at the time of building this invention on a UNIX system development machine. As UNIX development machine 20a, there are semaphore function manager section 21a which has a semaphore function manager, shared memory function manager section 22a which has a shared memory function manager, and signal function manager section 23a with a signal function manager. The following specifications are satisfied as UNIX development machine 20a.
(1) Don't need an I/O device specially.
(2) As an OS function to be used, the following three kinds are required.
** the function of shared memory function manager section 22a -- arrange to a shared memory so that a real-time system simulation process and a virtual device server can access the next area.
(a) Transmission buffer : Buffer which saves output data temporarily (b) Receive buffer : Buffer which saves input data temporarily (c) Device control register : The value which shows the instruction to a device and exit status is set.
(d) Interruption status bit field : the bit for the number of interruption which carries out a simulation is prepared.
** Signals SIGUSR1 and SIGUSR2 which a user can define as the software interrupt from the functional virtual device server of signal function manager section 23a to real-time system It is used.
** In order to avoid the race condition by asynchronous interruption from the virtual device server of functional plurality of semaphore function manager section 21a, use two kinds of semaphore function managers as follows. However, every semaphore of initial value is 1 (resource 1).
(a) The semaphore for interruption status bit change fields : prepare one semaphore in the whole simulation environment.
(b) The semaphore for interrupt requests : prepare a semaphore for every interruption class of virtual device server.
[0014] Real-time system simulation process section 10a is the following configurations.
** The simulation of the real-time system for the systems is faithfully carried out in the process of UNIX.
** It consists of an application task, real-time OS, and a device driver.
** Real-time OS contains IOCS (Input Output Control System) which controls and manages interruption from a device driver or a device.
** The interrupt handler for the systems is changed into a signal handler.
[0015] The virtual device server section 30a is as follows.
** The simulation of the actuation of a device is faithfully carried out so that there may be no access and difference in the I/O device of the system for real-time system simulation process 10a.
** Two or more virtual device servers are prepared for every device, and operate independently of each other.
** The data for device control registers used by asynchronous communication and a transmitted and received data can be created freely as follows.
(a) Carry out direct access of the actual device (hardware), and obtain data.
(b) A virtual device server creates or holds data uniquely. Use of a file is also possible.
(c) other processes -- or data is prepared from another development machine through a network.
[0016] Drawing 4 thru/or drawing 9 are flow charts which show actuation of the server 1 of real-time system simulation process section 10a at the time of data transmission and reception, and virtual device server section 30a. In detail, drawing 4 and drawing 5 are the flow charts at the time of interruption

generating according [drawing 8 and drawing 9] to a signal in drawing 6 and drawing 7 the time of data reception at the time of data transmission.

[0017] In addition, although the example showed the example which built the simulation system on a UNIX development machine, this invention is not limited to a UNIX development machine, and can build the simulation environment of communication system on development (for all, the name is registered trademark) machines, such as MS-DOS, OS/2, and Macintosh, VMS.

[0018]

[Effect of the Invention] As explained above, according to this invention, there are the following effects.

** It can be made to operate, without correcting the communication link application and the device driver of the system on a general-purpose development machine.

** If the simulation development environment of this invention is used, development and the communication link test of communication link application [from / before an I/O device is developed], or a device driver are possible.

** Since the asynchronous communication method with a virtual device server does not have a limit in the property and the number of an I/O device, it is applicable to the simulation of all the communication system of a world.

** The simulation development environment of the communication system of this invention can be used for research of a real-time communications protocol.

[Translation done.]